

From

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TRANS *magnetics, inc*

NEW CIRCUITS TO SOLVE UNIQUE DESIGN PROBLEMS

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From

TRANSMAGNETICS INC.

40-66 LAWRENCE ST
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NEW ADDRESS

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A NEW MANUAL:

New Circuits to Solve Unique Design Problems with:

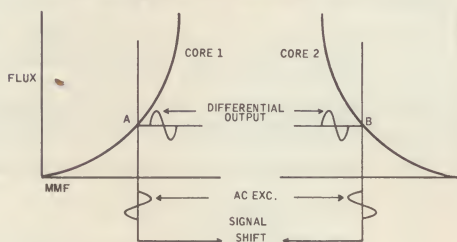
- MODULATORS
- MULTIPLIERS
- COMPARATORS
- CURRENT SENSORS
- AMPLIFIERS
- FAILURE MONITORS
- SIGNAL CONDITIONERS
- DIVIDERS
- ERROR DETECTORS



I INTRODUCTION

In a surprisingly wide range of applications illustrated by circuits in this manual, magnetic modulators can simplify circuit design, reduce size and weight and increase system reliability.

Theory of Operation of Magnetic Modulator



The Magnetic Modulator utilizes the non-linear B-H characteristics of magnetic material. Operation is illustrated for a two core modulator. With zero signal input, ac excitation input induces equal ac output in each core so that differential output is zero. DC signal input is applied on core 1 to shift operation to point with higher slope and more output, on core 2 to point with lower slope and less output. Fundamental differential output is generated proportional to signal input. Reversal of signal input polarity causes core 2 output to increase and core 1 to decrease, reversing output phase.

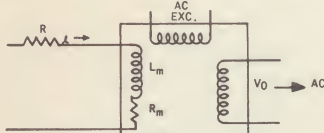
The Magnetic Multiplier works on the same principle since the output is also proportional to a.c. input. A modulator works in a mode where a.c. excitation sensitivity is minimized.

Magnetic Modulator Transfer Function

The magnetic modulator is a current input device equivalent to a single lag at the signal input. Its transfer function from signal input to output is:

$$i = \frac{V_{in}}{R + R_m + j\omega L_m}$$

$$V_o = K i$$



R is the external lumped signal loop resistance.

Time constant is $L/R + R_m$ and decreases as R increases.

V_o is fundamental a.c. when i is d.c.

2. MODULATOR CONVERTS DC TO AC

The magnetic modulator has an a.c. excitation and converts a low level dc signal input to a phase sensitive, sinusoidal fundamental, ac proportional signal. The modulation is suppressed carrier.

3. A MODULATOR MAY BE REQUIRED IN AN AC SYSTEM WHEN:

- The Input Transducer furnishes dc to modulate a carrier.

Typical Examples:

- | | |
|--------------------|----------------------|
| a. Potentiometers | i. Photo Cells and |
| b. Rate Generators | Photomultipliers |
| c. Thermocouples | j. FM discriminators |

- | | |
|------------------|------------------------|
| d. Magnesyns | k. Pressure |
| e. Strain Gauges | Transducers |
| f. DC Bridges | l. Accelerometers |
| g. Gyros | m. RF Detectors |
| h. Bolometers | n. Pulse coded signals |

- An ac Input must be converted to dc and will be converted back to ac because:
 - Servo stabilization and compensation must be performed at dc.
 - AC Quadrature signal must be minimized.
- The DC is Low Level and it is desired to perform amplification at ac, and convert back to d.c.

4. THE OUTPUT OF THE MODULATOR MAY BE:

- A Servo Motor. A power amplifier is generally required.
- A Phase Demodulator. The demodulator output is a polarity sensitive dc proportional to the in-phase fundamental output of the modulator and the dc input to the modulator.
- A Bridge Rectifier. The output is a non-reversing full wave rectified ac. A capacitor for filtering may be placed directly across the load.
- A Transistor Emitter Follower. This may furnish sufficient power output for many applications.
- A synchro Repeater System. The modulator furnishes a sine wave output.
- An Analogue Computer including resolvers. Sine wave is furnished.
- Amplitude Comparator.
 - Input Comparator. A reference dc may be applied to one input, the signal to the second input. An output is triggered by a small differential error in either direction.
 - Output Comparator. The rectified output may operate a Schmitt trigger, relay or SCR at a specified level.
- Failure Warning. Actuates flags and solenoids.

5. PHYSICAL CHARACTERISTICS

The basic configuration of the modulator is that of a transformer with a closed magnetic circuit on which multiple coils are wound. In addition resistors, capacitors, diodes and thermistors are used to achieve performance in characteristics such as gain, phase shift, temperature stability, linearity etc.

6. APPLICATIONS

A magnetic modulator may be required when one or more of the following conditions obtain:

- Long Life Required.

Magnetic modulators will last indefinitely, performing to specifications, when subjected to extreme environmental conditions. There are no moving parts and the parts used are rugged and reliable.

- Wide Temperature Range.

Magnetic Modulators perform to specifications on drift, phase angle, gain etc. from -85 to +150°C.

- Multiple Inputs and Outputs.

Isolated multiple inputs are available so that addition and subtraction of inputs can be accomplished

within the modulator. Multiple isolated outputs are available for dual outputs.

4. Carrier Frequency.

Magnetic modulators will perform up to 120 KCS.

5. Isolation.

All signal inputs, excitation, and outputs are isolated from each other and from ground.

6. Common-Mode Rejection.

The signals can be placed directly across the input generating differential output with high common-mode rejection.

7. Sinusoidal Output.

Distortions as low as 1% can be achieved. Synchro and resolver follow-up systems among others, require an inherently sinusoidal signal for proper operation. Choppers, mechanical and transistor, furnish square wave output requiring filtering to achieve a sinusoid, which is inherently furnished by the magnetic modulator.

8. Voltage Gain.

Because of the inherent transformer construction, voltage gain may be achieved equivalent to a step-up ratio in transformers.

9. Power Gain.

Power Gains of 1000 can be achieved, measured from signal to output. The excitation supplies the gain.

10. Size.

Can sizes as small as 3/4 cu. in.

11. Weight.

As low as 1 ounce, fully potted.

7. PERFORMANCE CHARACTERISTICS OF MAGNETIC MODULATORS

Design parameters include the following:

Gain	Carrier Frequency
Input resistance	Null
Drift	Linearity
Frequency Response	Distortion
Output Phase	Overloading

The designer is interested in the range of these characteristics, and in their stability with temperature and environmental conditions.

Gain is measured as a.c. volts out/d.c. current in. This characteristic is shared with magnetic amplifiers. Gains of 400 mv/ua are achieved. In general, higher current gains are associated with higher input resistance.

Gain can be held constant to within 2% over -55 to +105°C.

Input Resistance ranges from zero to 50,000 ohms. The modulator can be designed without electrical connection, the input wire passing through and linking the magnetic circuit of the modulator. The effective input resistance can be increased by potentiometric feedback.

Windings are usually copper which has a temperature coefficient of approximately 0.4% per C. This can be compensated to remain constant within 2% over a range from -55 to +85°C.

Drift. In a.c. servo applications, the output of interest is often the in-phase fundamental component. With temperature variation, this component of the modulator output may change. Drift is the change in signal current to maintain this component at zero. Input Power stability as low as 6 micro-microwatts from -85 to +105°C can be achieved. This corresponds to 100 microvolts at 1500 ohms input resistance.

Frequency Response.

Signal band width is proportional to input loop resistance and can extend up to and past the excitation frequency. Frequency response is primarily determined by the R/L ratio of the input circuit as shown in Figure 2. It increases with fewer turns on the signal winding since L increases as the square of the turns and R linearly. Source resistance increases the R/L ratio and the bandwidth. A typical 3 db bandwidth is 125 cps with 20K source for a 2500 ohm input with 400 cps excitation.

Note that the modulator does not have the delay term associated with magnetic amplifiers which essentially sample the signal at twice the excitation frequency. The magnetic modulator operates continually in time without sampling.

Phase.

The output phase can be held within 2 degrees (with respect to input excitation) over full signal swing and -65 to +105°C. The nominal phase can be specified to lead or lag the excitation.

Null.

The magnetic modulator has a minimum output (null) primarily 2nd harmonic with some 3rd. Quadrature fundamental output is negligible in most models. The harmonic terms arise from internal incomplete cancellation.

Null amplitude can be held to 1/4% of maximum output over temperature.

Offset is the amount of signal input required to give zero in-phase fundamental output. Change of offset with temperature is drift. Offset at a specified temperature can be held as closely as desired. In addition a centering winding is often furnished. This is a convenient way to balance or adjust a servo system zero position, or offset for a comparator.

Linearity.

Linearity of output vs. d.c. input can be held to within 1/2% of full scale. In general, linearity will be maintained with temperature variation, although the absolute gain may change as described above under Gain.

Distortion.

Distortion may be held under 1% of FS and is mostly 3rd harmonic at high output, 2nd harmonic at null. Distortion increases with higher excitation drive which also increases gain. Higher hysteresis is associated with lower drive.

Overloading and Hysteresis.

Hysteresis referred to the input is the change in d.c. input required to give the same output after a signal excursion and can be held to 0.1% of the maximum input excursion. For severe input overloading, the output saturates and may even decrease. This can be avoided by proper design of the modulator in relation to possible overload or by use of a pair of limiting diodes, back to back, across the signal input.

8. SPECIFYING AND ORDERING MAGNETIC MODULATORS

The following information will enable Transmagnetics to furnish modulators optimized for the application.

1. A brief statement of the application.
2. Temperature range of operation.
3. Input resistance desired.
4. Preferred load resistance.
5. Signal input range, whether bidirectional, and gain.
6. Description of signal input source.
7. Description of output device including how used (i.e., rectified, phase demodulated, etc.)
8. Important parameters such as drift, phase, linearity etc.
9. Preferred excitation voltage, if any and frequency.

APPLICATIONS OF MAGNETIC MULTIPLIERS

A magnetic multiplier is a magnetic modulator in which the a.c. input amplitude is permitted to vary and a phase sensitive fundamental output accurately proportional to the product of the ac and d.c. inputs is required.

The output signal is fundamental and is applied directly for follow-up by servo motor, synchro, resolver and similar a.c. control systems.

The magnetic multiplier is a basic element in non-linear analog computing control systems involving algebraic addition, multiplication, division and all other functions which can be synthesized from these operations.

The advantages of the magnetic multiplier lie in its small size, (1 cu. inch) extremely high life, radiation resistance, reliability and repeatability under extreme environmental conditions, and in its accuracy.

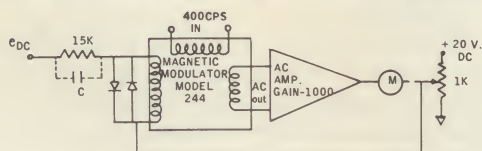
The multiplier can be used to compute electrical and mechanical power, energy, torque and other quantities involving the product of two measureable inputs and may be used for squaring and analog division.

Multiplication and algebraic addition are performed directly in the multiplier without requiring sign-changing or adding amplifiers.

APPLICATIONS ARE ILLUSTRATED IN A NUMBER OF CIRCUITS IN THIS MANUAL.

CASE HISTORY #1

DC Input Position Follow-Up Servo



MAGNETIC MODULATOR COMPARES DC INPUT AND FOLLOW-UP AND GENERATES PROPORTIONAL A.C. ERROR SIGNAL IN HIGH SPEED PERFORMANCE POSITION SERVO.

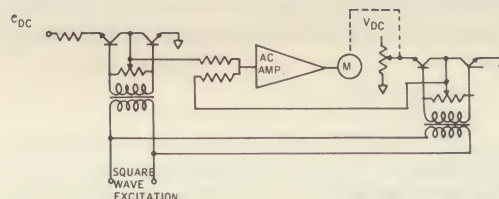
System illustrated has better than 0.1% static accuracy over -55 to +85°C. Modulator transfer function is essentially a single lag with less than 3 millisecond time constant. Modulator output is full-wave and sinusoidal. Capacitor across 15K will give lead compensation. Diodes prevent offset due to large servo error possible at start-up.

ADVANTAGES: No moving parts
Sine wave output
Multiple isolated inputs available
Long Life

REQUEST MODEL 244 MODULATOR DATA SHEET.

CASE HISTORY #2

Comparison of Magnetic Modulator with Solid State Choppers in Servo Use

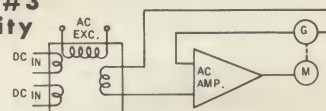


Magnetic modulator replaces two SPDT choppers, two nulling potentiometers, two excitation transformers and two adding resistors. In the chopper modulator, adding resistors load source and feedback potentiometer, decreasing accuracy; input and follow-up must be of opposite polarity; adding is a.c. with phase and wave shape errors; chopping is half-wave with attendant servo stability problem; full wave modulation requires additional signal transformer for transistor choppers; spikes, switching transients, square wave cause filtering problems.

DC servo stabilization with lag-lead networks and/or tachometer is not easily introduced. Magnetic Modulator works on sine-wave excitation, instead of square wave.

CASE HISTORY #3

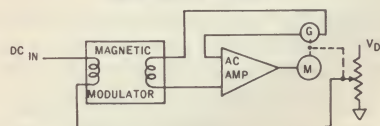
DC Input Velocity Servo - AC Tachometer Feedback



DC to AC conversion of magnetic modulator is linear. Tachometer feedback causes speed to be proportional to DC inputs. Modulator distortion is low, phase held closely constant over full temperature. Multiple inputs may be added algebraically with complete isolation. High common mode rejection.

CASE HISTORY #4

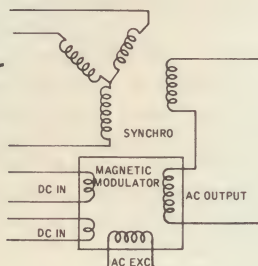
DC Input Position Servo. AC Tachometer Stabilization



Tachometer stabilization is added in series with modulator output. Modulator has low drift, low phase travel.

CASE HISTORY # 5

Magnetic Modulator Solves Problem of Adding AC Synchro Output to DC



In servo system design, multiple inputs present a problem if d.c. inputs are to be added algebraically to a.c. inputs.

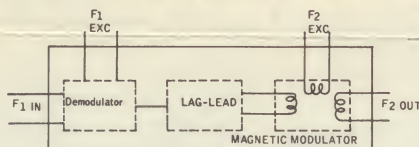
The modulator output is a low distortion sine wave which is linear with the algebraic sum of the isolated dc inputs. Quadrature is held to a low value over the full temperature range.

For synchro follow-up of a dc input, the combined output is fed to an amplifier and motor which rotates the synchro rotor until the synchro output is equal to the modulator output.

REQUEST MODEL 245

CASE HISTORY # 6

Frequency Conversion of Servo Carrier

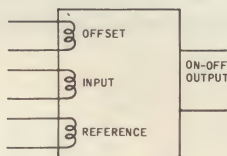


A carrier error or follow up signal of one frequency is converted to a proportional signal of a different frequency. Thus: a 60 cps error signal is converted to 400 CPS.

Servo stability for high performance is facilitated by insertion of lag-lead networks at d.c. Frequencies from 50 cps to 120KC may be converted in either direction. Quadrature rejection is high, output is sinusoidal.

CASE HISTORY # 7

Bi-Directional DC Voltage and Current Comparator



Multiple floating, variable d.c. voltages or currents may be compared with microampere sensitivity in magnetic modulator to furnish high power, on-off output at specified limits. Unit responds when either input exceeds the other. Unequal inputs may be compared. Scale factor is introduced by unequal turns ratio on input windings or series resistor trimming.

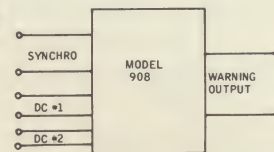
Adjustable unequal positive and negative firing points can be achieved by an additional off-set d.c. input winding.

The following outputs can be supplied:

1. On-Off 28V. High Power (SCR)
2. Peak detection
3. Schmitt trigger
4. Operate relay, lamp, flag, actuator
5. No output below limits, output proportional to error above limits (for meter movement).

CASE HISTORY # 8

Failure Monitoring with Fail Safe Output, AC and DC Inputs, Logic Response



Typically, monitoring a synchro output null will give warning of servo failure. Monitoring a power supply voltage can give notice of over or under voltage.

Failure of any one of multiple ac and dc voltage or current inputs can be detected by input response with OR, AND Logic and combinations therefore.

The system is illustrated with an ac synchro null and 2dc supply voltage inputs. An output is produced IF AND ONLY IF:

The synchro null remains below a specified level
AND:

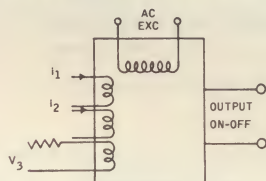
Supply #1 is above the specified value

AND Supply #2 is below its norm

Outputs to operate lamps, flag warning, meters, solenoids, actuators, relays and motors with outputs ON-OFF or proportional to error are available.

Request Model 908 Failure Warning Data Sheet.

CASE HISTORY # 9



Programmable Sensitive Switch-Comparator

Output triggers 28V, 200 MA power source on or off with 1-1/2 millivolt sensitivity over -55 to +85°C.

Will furnish GO-NO output for combinations of input voltage and current.

Thus when $K_1 I_1 + K_2 I_2 + K_3 V_3 \geq 0$, the output will trigger ON or OFF.

For voltage or current sensing, one input can be programmed for comparison with a test input.

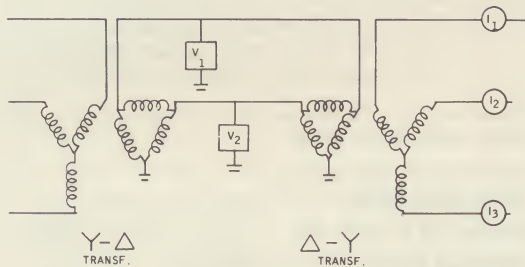
The unit can be used as a sensitive solidstate switch.

For process control, multiple comparators may be arranged to generate control ON-OFF outputs at adjustable levels within the range of the input. Thus valves, solenoids etc. may be actuated below or above different speeds of a pump.

REQUEST MODEL 905 DATA SHEET

CASE HISTORY #10

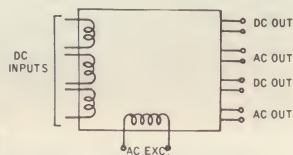
Universal Failure Monitoring for 3-Phase Power



Device monitors voltages and currents in 3-Phase Aircraft Supply and operates warning when one or more voltage and currents drop. Logic circuitry simplifies and cuts cost of device.

CASE HISTORY # 11

Multiple DC and Sinusoidal Isolated AC Outputs from Isolated DC Inputs



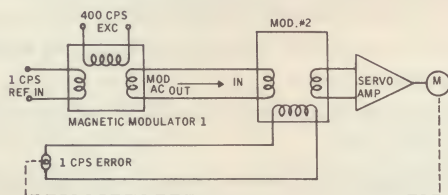
Modulator acts as a chopper to convert low level d. c. to high level a. c. and d. c. outputs. Inputs and outputs are completely floating, isolated from each other, power line and ground. Inputs can be insulated for thousands of volts. AC outputs can drive synchros, motors resolvers. DC outputs drive meter indicators, d.c. motors, and follow-up systems. Extreme reliability is achieved; shorting one output does not affect the others. Dual outputs provide switchover in case of failure.

Other Advantages of this Configuration:

1. Compact, light weight
2. Low power consumption
3. Phase sensitive
4. Linear
5. Low Drift
6. Long Life

CASE HISTORY # 12

Demodulation and Remodulation of Low Frequency Error Information in Servo Control



In many tracking systems, target direction, range or velocity information are often contained in the amplitude or phase of a low frequency (1 CPS for example) modulation. In an automatic control loop, the low frequency is demodulated, and remodulated on to a 400 CPS carrier to drive a servo feedback system for zero error. The output must be phase sensitive. This can be simply and reliably accomplished with two magnetic modulators:

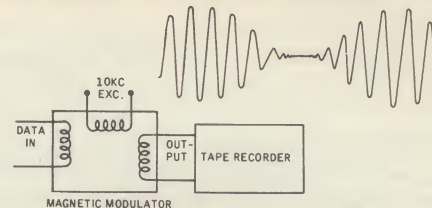
Consider a 1 CPS reference square wave applied to signal input of magnetic modulator #1. Then the 400 CPS output of Modulator #1 which is the excitation for Modulator #2 will reverse phase at a 1 CPS rate. With zero 1 CPS error signal applied to Modulator 2, there will be no output. Now consider a 1 CPS error signal in phase with the reference. During the positive half of the 1 CPS signals there is a 400 CPS output driving the servo motor. During the negative half cycle both the 400 CPS excitation and the error signal applied to Modulator 2 reverse. The modulator is a four quadrant multiplying device and the 400 CPS output does not reverse phase when both signal and excitation reverse. Thus the motor continues to drive in the same direction until the 1 CPS error amplitude is reduced to zero.

The same system can be used to control the phase of the 1 CPS error signal. In this case, when the 1 CPS error signal is 90 degrees from the reference, the output phase reverses half way during each reference half-cycle due to error reversal. The average torque on the motor is zero since the motor tries to turn in opposite directions half the time. If the error phase is greater than 90 degrees there will be a net torque in one direction and in the opposite direction when the phase is less than 90°.

The operation is similar to a vibrating relay proportional control device.

CASE HISTORY # 13

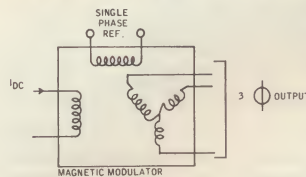
Data Storage with Suppressed Carrier Modulator



Suppressed carrier application is illustrated with data recording. Data with 1 KC Bandwidth may be stored on tape by amplitude modulating onto a 10 KC carrier. Modulators are available with carriers from 50 CPS to 120 KC, carrier output distortion to 1% and phase shift to 1 degree.

CASE HISTORY # 14

3 Phase Output with DC Input

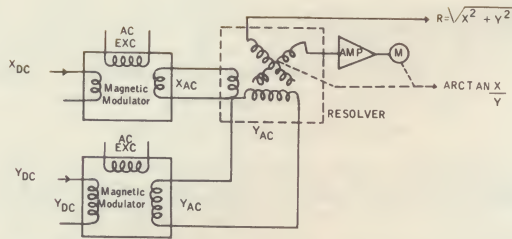


The 3 phase output is the same frequency as the reference, with amplitude proportional to dc input and with 120 degree phasing.

CASE HISTORY # 15

Generating $\sqrt{X^2 + Y^2}$ and $\text{ARC TAN } \frac{X}{Y}$ from DC Inputs in Carrier Systems with Magnetic Modulator

The magnetic modulator ac outputs are linear with the dc inputs, sinusoidal with low quadrature and dis-



tortion over wide temperature. The modulators are stable, radiation resistant, reliable with very long life. Full four quadrant operation is achieved.

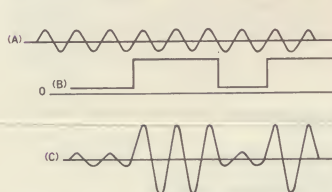
This system eliminates sine-cosine potentiometers and provides carrier outputs directly.

Request Model 139 Modulator Data Sheet.

CASE HISTORY # 16

Amplitude Modulating a Sinusoidal Carrier with Pulse Coded Information

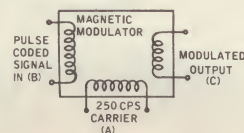
The magnetic modulator is an extremely reliable, compact and radiation resistant method of amplitude modulating a carrier with pulse coded information and furnishing a sinusoidal output. This results in a considerable saving in bandwidth as compared to modulating on a square wave.



The pulse coded information level changes occur synchronized with the zero cross-over of the carrier input.

This system is in accordance with Atlantic Missile Range requirements.

Request Data Sheet on Model 147 Modulator.

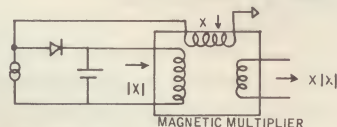


CASE HISTORY # 17

Computing $X|X|$ in a Control System with Magnetic Multipliers

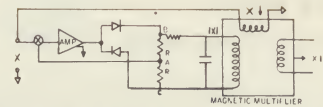
With a 400 CPS (typically) carrier signal, X , available, it is required to accurately generate $X|X|$ (X times the magnitude of X) at 400 CPS output to operate a control system.

A simple approach is shown first:



Rectification produces a non-reversing dc input to the multiplier proportional to X , which does not reverse when the phase of X reverses. X is also applied directly to the multiplier a.c. input. The output is sinusoidal with the same frequency and phase as X , with amplitude proportional to X^2 .

However the diode introduces non-linearity at low levels and temperature variation. A more sophisticated approach is shown below.



The output at A is a.c. reconstituted from the half waves at B and C. The resultant multiplier input is d.c. proportional to the rectified differential output between B and C and precisely proportional to the a.c. at A. With feedback and high gain amplification, the output at A is made equal to X and the d.c. linearized with X .

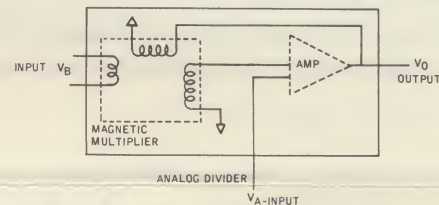
The d.c. does not reverse when X changes phase, so that a dc $|X|$ has been generated.

The second input to the multiplier is X , resulting in an output $X|X|$, i.e. a sinusoid at carrier frequency, with amplitude proportional to X^2 and phase reversing with the input.

CASE HISTORY # 18

Analog Division with Magnetic Multiplier in Control Carrier Systems

The addition of an a.c. feedback amplifier to the magnetic multiplier results in an analog divider



$$V_O = K V_A / V_B$$

V_B is a dc input

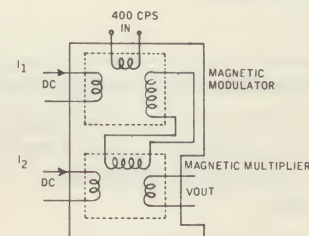
V_A is a 400 CPS (typically) signal

The output V_O is a 400 CPS phase reversing signal.

Request Model 404 Data Sheet.

CASE HISTORY # 19

Multiplication of DC Inputs with Carrier Control Signal Output



One dc input is applied to the magnetic modulator with 400 CPS excitation which furnishes a proportional 400 cps input to the multiplier.

The second d.c. input is applied directly to the multiplier. The output is 400 CPS with 4-quadrant characteristics proportional to the product of the d.c. inputs.

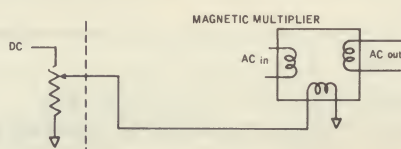
See Model 305 Data Sheet.

CASE HISTORY # 20

Remote Control of AC Gain

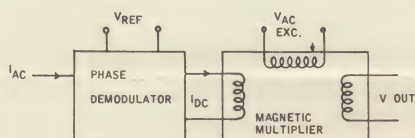
A requirement for remotely controlling the level in an a.c. system has meant running the ac to a potentiometer (located perhaps on an instrument panel) and back again. This introduces the danger of pick-up and phase shift, especially at high frequency.

The magnetic multiplier acts as a variable electronic attenuator controlled by a dc input from a potentiometer located wherever desired. 100:1 Dynamic range can be achieved. Interference and variation of source impedance are avoided. Carrier Frequencies to 120KC are accommodated. For dc signal conversion, a magnetic modulator will convert and drive the multiplier.



CASE HISTORY # 21

True AC Power Measurement with AC Output for Servo Follow-Up



I_{DC} equals $I_{AC} \cos B$

Where B is the phase angle between I_{AC} and the reference.

V_{out} equals $V_{AC} I_{AC} \cos B$ and is a 400 CPS phase reversing output proportional to true power when V_{REF} and V_{AC} have a common origin. The output may be used for feedback control, i.e. to maintain power constant, since it is phase reversible.

Transmagnetics Application Department

Transmagnetics is prepared at all times to advise and recommend on feasibility of proposed applications. Tell us enough to analyze your requirement. You will hear from us promptly.

MORE DATA IN EEM

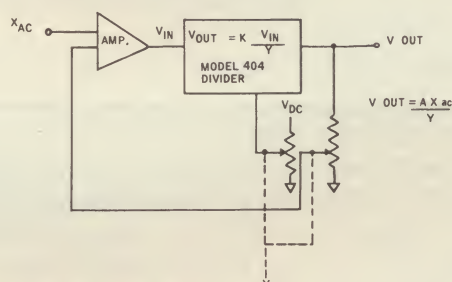
WRITE OR CALL FOR DATA SHEETS OF INTEREST

CASE HISTORY # 22

Gain Stabilization of Non Linear Computing Servos with Magnetic Divider

In dividing, angle generating and other non-linear computing servos, optimum speed and accuracy cannot be achieved because the loop gain varies with signal amplitude and a servo stabilized for operation at the point of high gain will be sluggish elsewhere.

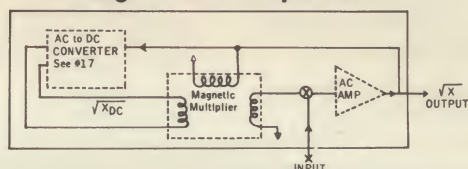
Performance may be optimized by a divider as shown for an a.c. precision dividing servo.



Normally, the loop gain varies directly with y , so that accuracy and speed will be high only at large values of y . Divider Model 404 inserted as an element in the loop has a gain varying inversely with y . Thus the over all loop gain becomes independent of y and the system can be stabilized for high performance over a large variation in y .

CASE HISTORY # 23

Generating Square Roots in Carrier Control Systems with Magnetic Multipliers



X is a carrier sinusoidal input (typically 400 CPS). The output is fundamental sinusoidal with amplitude proportional to square root of the input amplitude and phase reversible with the input.

CASE HISTORY # 24

Charge Amplifier

Charge Amplifier amplifies piezoelectric transducer output. Output voltage is proportional to transducer charge output and thus to force or pressure. Calibration is independent of cable length with input impedance level considerably below conventional amplifiers.

TRANS *magnetics, inc*

LENEX 9-2750 • CODE 212

T X M

40-66 LAWRENCE STREET
FLUSHING 54, NEW YORK

TRANSMAGNETICS
INC.

SINE WAVE
MODULATORS

ANALOG
MULTIPLIERS
DIVIDERS,
SQUARERS
AND SQUARE
ROOTERS

CURRENT
SENSORS

SENSITIVE
MAGNETIC
AMPLIFIERS

FREQUENCY
TO DC
CONVERTERS

DEMODULATORS
AC TO DC
CONVERTERS

SENSITIVE
SOLID STATE
RELAYS AND
MONITORS

COMPARATORS

SCR SERVO
DRIVES



CATALOG
665

TRANS MAGNETICS INC.

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MODULATORS • DEMODULATORS • ANALOG MULTIPLIERS
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MODEL 195A

DC-100 KC BANDWIDTH
MULTIPLIER-MODULATOR

$V_o = .3V_1 V_2$

V_1, V_2 each 0 to ± 1 V into 100 Ω

ACCURACY: $\pm 2\%$ FS

NULL: Less than 1% FS with 1 input zero, 2nd input at Full Scale (400 CPS)

POWER: +15 V DC @ 20 MA Max
-15 V DC @ 5 MA Max

MODEL 650

"SOLID-STATE"
SYNCHRO TRANSMITTER
without moving parts

ACCURACY: to 6 minutes

OUTPUT: 3 wires, 11.8 V 400 CPS L. to L. to drive. 2 Size 11 Synchro Receivers

INPUTS: 0 to ± 10 VDC proportional to sine and cosine of the angle

POWER: 40 VDC; 26V 400 CPS

Also available with input DC proportional to the angle instead of the sine and cosine

MODEL 335

1/5 CU. IN. AC SWITCH

AC signal switched on by 2 V DC at 200 μ A

SIGNAL IN: 0 to 5 V, 50 to 1000 CPS

ON OUTPUT: 0 to 1 V, 10 K source imp.

OFF OUTPUT: 3 MV Max

SWITCHING TIME: 10 μ s Max

SIZE: .56" sq. x 0.4", PC leads on 0.2" grid

OPERATING TEMPERATURE: -55 to +105°C

SENSITIVE SOLID STATE CONTROL RELAYS

LEVEL DETECTORS: for FAILURE DETECTION • ALARM MONITORING • ANALOG TO ON/OFF • LIMIT SWITCHING

MODEL	DETECTS	SET POINT	OUTPUT ON WHEN INPUT LEVEL	INPUT IMPEDANCE	SIZE	POWER	OUTPUT
916	AC Level	1 to 26 V, 400 CPS	Higher Than Set Point	30 K Ω	1 $\frac{1}{2}$ " Sq. x 1 $\frac{1}{2}$ "	26 V, 400 CPS	27 V DC @ .2A
940	AC Null Level	50 MV to 1 V, 400 CPS	Below Set Point	30 K Ω	1 $\frac{1}{2}$ " Sq. x 1 $\frac{1}{2}$ "	26 V, 400 CPS	27 V DC @ .2A
922	(Amplifier Input) > Set Point	15 to 200 MV DC	Between + and - Set Point; Off Above + and Below - Set Point	30 K Ω	1 $\frac{1}{2}$ " Sq. x 2 $\frac{3}{8}$ "	26 V, 400 CPS	27 V DC @ .2A
960	Logic Response, Low DC, and/or High AC Null	+15 V DC and 1 V, 400 CPS	Both DC Input Above and AC Input Below Set Point	30 K Ω	1 $\frac{1}{8}$ " x 1 $\frac{1}{4}$ " x 1 $\frac{1}{8}$ "	26 V, 400 CPS	27 V DC @ .2A

COMPARATORS:

MODEL	DETECT INPUTS	RANGE	OUTPUT ON WHEN	INPUT IMP.	SIZE	OUTPUT	POWER
982	A > B	0 - 1 MA DC	A > B	700 Ω EA.	1 $\frac{1}{2}$ " Sq. x 2 $\frac{3}{8}$ "	27 V DC @ .2A	26 V, 400 CPS
970	A-B > 0	-1.5 - +1.5 V DC	A-B > 0	10 K Ω EA.	1 $\frac{3}{4}$ " x 1 $\frac{1}{8}$ " x 2 $\frac{3}{8}$ "	27 V DC @ .2A	26 V, 400 CPS
984	A > B	0 - .5 V, 400 CPS	A > B	10 K Ω EA.	1 $\frac{1}{2}$ " Sq. x 2 $\frac{3}{8}$ "	27 V DC @ .2A	26 V, 400 CPS

BINARY SWITCHING OUTPUTS FROM ANALOG INPUTS:

MODEL	DETECTS	OUTPUT #1 ON	OUTPUT #2 ON	INPUT IMP.	POWER	OUTPUT	SIZE
930	High Low AC Current	Input > 200 MA	Input < 20 MA	< 5 Ω	26 V, 400 CPS	27 V DC .2A EA.	1 $\frac{3}{4}$ " x 1 $\frac{1}{8}$ " x 2 $\frac{3}{8}$ "
983	3 Level AC Input 0 to 125 V, 400 CPS	ON: 10 < V < 40; OFF: V < 10; V > 40	ON: > 40 OFF: < 40	> 100 K Ω	26 V, 60 CPS	27 V DC .2A EA.	1 $\frac{1}{2}$ " SQ. x 2 $\frac{3}{8}$ "

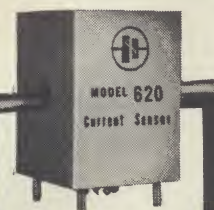
CURRENT SENSORS - CONDITIONERS

OVERCURRENT SWITCHING - TELEMETERING:

MODEL	INPUT	INPUT RES.	SENSING HOLE	OUTPUT	LOAD	POWER	SIZE	OPER. TEMP.
620	0 to 20A DC	—	$\frac{3}{8}$ "*	0 to 5 V DC	5 K Ω	40 V 400 Ω	1 $\frac{3}{4}$ " x 1 $\frac{1}{8}$ " x 2 $\frac{3}{8}$ "	-55 to +85°C
630	0 to 1A 400 CPS	< 1 Ω	—	0 to 5 V DC	5 K Ω	18 V DC	1 $\frac{1}{2}$ " Sq. x 1 $\frac{1}{8}$ "	-30 to +71°C
660	1 to 5A DC	—	$\frac{3}{2}$ "*	.5 to 3.5 V DC	600 Ω	20 V PP 18 KC	$\frac{3}{4}$ " D x $\frac{1}{2}$ "	-55 to +85°C

* Wire passes through without line interruption.

THIS SHEET FOR REFERENCE. DETAILED DRAWINGS AND SPECIFICATIONS ARE AVAILABLE ON REQUEST.



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SINE WAVE MODULATORS

for DC to LOW DISTORTION AC PROPORTIONAL OUTPUT



Fully Isolated Input, Output, Excitation
 DRIFT: To 100 μ V over -55 to $+105^{\circ}\text{C}$
 LINEARITY: To 0.05% FS
 GAIN STABILITY: To 0.1% over -55 to 105°C
 NULL: To 500 Microvolts
 CARRIER: 50 CPS to 500 KC
 POWER OUTPUT: To $3\frac{1}{2}$ Watts

SIZE: As small as $\frac{1}{3}$ cu. in.
 WEIGHT: Down to $\frac{1}{2}$ oz.
 DISTORTION: As low as 1%
 HYSTERESIS: To essentially zero
 MULTIPLE INPUTS: For Algebraic Addition
 Full Wave Modulation — Phase Sensitive
 Current or Voltage Conversion
 VOLTAGE INSULATION: To 2000 volts



MODEL 146
 1/3 Cu. in.
 servo mod.

MODEL 165
 1 cu. in.
 0.2% Lin.

MODEL 169
 1 $\frac{1}{2}$ cu. in.
 5V. out, low null

MODEL 152
 0.1% Lin.
 precision

MODEL 191
 5V out
 0.2% Lin.

MODEL 214
 Low Null
 Fast response

MODEL 175
 Multiplying
 modulator

MODEL 140
 4 isolated inputs
 add. & sub.

MODEL 120
 2000V sig.
 insulation

MODEL 172
 30 KC
 Carrier

MODEL	120	140	146	152	165
Input Signal — DC	#1 = 0 to $\pm 200 \mu$ A #2 = 0 to $\pm 500 \mu$ A	4 Inputs Each 0 to $\pm 150 \mu$ A	0 to $\pm 100 \mu$ A	0 to ± 7 V	0 to ± 7 V
Input Impedance	1 K Ω ea. max.	1 K Ω Each	10 K Ω max.	100 K Ω min.	100 K Ω min.
Output — AC	0 to ± 2.4 V	0 to ± 2 V	0 to ± 2 V	0 to ± 1 V	0 to ± 1 V
Output Load	50 K Ω	20 K Ω	10 K Ω	50 K Ω	50 K Ω
Linearity	3% FS	3% FS	2% FS	0.1% FS	0.2% FS
Gain Stability Over -55 to $+85^{\circ}\text{C}$	10%	10%	10%	3% (0.1% Special)	3% (0.2% Special)
Null	20 MV	30 MV	10 MV	3 MV	5 MV
Null Drift Over Temperature	20 MV	20 MV	5 MV	1 MV	1 MV
Phase Shift	$\pm 5^{\circ}$	$\pm 10^{\circ}$	$\pm 10^{\circ}$	$\pm 3^{\circ}$	$\pm 5^{\circ}$
Distortion	30%	5%	20%	2%	2%
3 DB Band Width — CPS	13 (15 K Ω Source)	13 (15 K Ω Source)	300	200	300
Excitation	26 V, 400 CPS	26 V, 400 CPS	23 to 29 V 380-420 CPS	26 V, 400 CPS	115 V, 400 CPS
Size — Inches	1 $\frac{1}{2}$ Sq. x 2 $\frac{1}{4}$	1 $\frac{1}{2}$ x 1 $\frac{1}{4}$ x 1 $\frac{1}{2}$	.763 Sq. by .61 In. on PC GRID	1 $\frac{1}{2}$ x 1 $\frac{1}{4}$ x 1 $\frac{1}{2}$	$\frac{1}{2}$ x 1 $\frac{1}{2}$ x 1 $\frac{1}{4}$
Weight — Oz.	8	4.5	0.5	4.5	1

SEE OPPOSITE PAGE

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AC-DC CONVERTERS

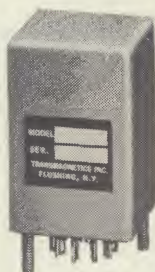
OUTPUT IS PROPORTIONAL TO MAGNITUDE OF
 AVERAGE OF FULLWAVE RECTIFIED INPUT



MODEL	INPUT	INPUT IMPEDANCE	OUTPUT	LOAD	LINEARITY	STABILITY -40 to +71°C	SIZE	POWER SUPPLY
638	DC and AC, 60 to 5000 CPS, 0 to 50 MV	100 KΩ	0 to 1MA. DC	250 to 1500 Ω	±0.5% FS	1%	2" x 2" x 3"	25-31 V DC 15 MA. MAX. +44 MA. Relay to select AC or DC input
625	0 to 5 V RMS 400 CPS	30 KΩ	0 to 5 V DC	50 KΩ	±0.5% FS	1%	1 1/2" Sq. x 1 1/4"	18 V @ 20 MA
643	.2 to 1 AMP., 400 CPS	< .05 Ω	0 to 5 V DC	100 KΩ	±1%	2%	1 1/2" Sq. x 1 1/4"	30 V @ 10 MA

DEMODULATORS, PHASE SENSITIVE

for AC TO DC PROPORTIONAL CONVERSION



MODEL	835	840	845	850	855	860
AC Input	0 to 10 V 400 CPS	0 to 5 V 400 CPS	0 to 85 MV 400 CPS	0 to 5 V 400 CPS	0 to 10 V 400 CPS	14 V Peak 400 CPS
Input Impedance	30 KΩ MIN.	50 KΩ MIN.	100 KΩ MIN.	100 KΩ MIN.	12 KΩ	Equals Load
DC Output	0 to ±10 V	0 to ±4.3 V	0 to ±150 μA	0 to ±4.5 V	60 MV/degree Around Quadrature 500 to 1 Quad. Rej.	10 MA MAX.
Into Load	100 KΩ	100 KΩ	500 Ohm Meter	50 KΩ	10 KΩ Resistive	—
Excitation	115 V 400 CPS	26 V 400 CPS	26 V 400 CPS	+25 V DC 115 V 400 CPS	8 V P.P. Sq. Wave 400 CPC ±15 V DC	6 V, 400 CPS Internal Transformer
Null	0.5% FS	0.5 MV	1 μA	0.06% FS	6 MV	3 MV
Linearity	1.0% FS	0.1% FS	2% FS	1% FS	0.5% FS	—
Gain Stability over -55 to +85°C	2% STD.	1%	2%	5%	1%	—
3 db Freq. Response	100 CPS MIN.	150 CPS MIN.	10 CPS	To 300 CPS External Filter. Unfiltered Internally	To 300 CPS External Filter. Unfiltered Internally	—
Ripple	100 MV MAX.	1%	—	—	—	—
Size	1 1/2" SQ x 2 1/8"	1" x 1" x 1 1/8"	1 7/8" x 1 3/4" x 2 3/8"	1" x 1" x 1 1/8"	1 1/8" x 1 1/4" x 1 7/8"	3/4" SQ. x .6"
Weight—Oz.	4	2.5	4	2.5	4.5	0.5

SEE OPPOSITE PAGE

MODEL	169	172	175	191	214
Input Signal — DC	0 to ±200 μa	0 to ±300 μa	0 to ±5 V	0 to ±5 V	0 to ±7 V
Input Impedance	10 KΩ max.	12 KΩ max.	50 KΩ min.	10 KΩ min.	100 KΩ min.
Output — AC	0 to ±5 V	0 to ±2 V	0 to ±1 V	0 to ±5 V	0 to 1.5 V
Output Load	20 KΩ	10 KΩ	10 KΩ	50 KΩ	50 KΩ
Linearity	2% FS	5% FS	1% FS of DC 1% FS of AC	0.2% FS	0.5% FS
Gain Stability Over -55 to +85°C	5%	5%	2%	8%	5%
Null	5 MV	50 MV	10 MV	5 MV	1.5 MV
Null Drift Over Temperature	2 MV	50 MV	10 MV	3 MV	1 MV
Phase Shift	±5°	Not Controlled	±10°	±5°	±3°
Distortion	5%	10%	10%	2%	2%
3 DB Band Width — CPS	300	1 KC	50 (15 KΩ Source)	300	< than 3° Phase Shift at 30 CPS Modulation
Excitation	26 V, 400 CPS	5 V, 30 KC	26 V ± 10% 380-420 CPS	26 V, 400 CPS	26 V, 400 CPS
Size — Inches	1/2 x 1 1/8 x 2 1/4	1 3/4 x 1 7/8 x 3/4	1 1/8 x 1 1/4 x 1 7/8	1 1/8 x 1 1/4 x 1 7/8	1 1/8 x 1 1/4 x 1 7/8
Weight — Oz.	1.2	2	3.5	4.5	4.5

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MULTIPLIERS • DIVIDERS (VARIABLE GAIN AMPLIFIERS)

MODEL 300 AX
AC × DC = AC



MODEL 340
DC × DC = AC



MODEL 350
DC × DC = DC

MODEL 360
AC × DC = DC

MODEL 430
AC ÷ AC = AC

MODEL 440
AC ÷ DC = AC

for MULTIPLICATION • DIVISION • SQUARING • SQUARE ROOTING

MODEL	FUNCTION	INPUT A	INPUT B	INPUT A IMPED.	INPUT B IMPED.	OUTPUT	LOAD	LIN- EAR- ITY	Gain Stability -55 to +85°C	SIZE
300AX	$V_O = K(I_{A1} + I_{A2})V_B$	0 to $\pm 100 \mu A$ EA. DC	0 to 2 V, 400 CPS	2600 Ω EA.	500 Ω	0 to 1 V, 400 CPS	10 K Ω	2%	2% Std.	1" x 1 1/2" x 1 1/2"
340	$V_O = K V_A V_B$	0 to ± 10 V DC	0 to ± 10 V DC	100 K Ω	100 K Ω	0 to 1 V, 400 CPS	10 K Ω	2%	2% Std.	1 1/2" Sq. x 2 3/8"
350	$V_O = K V_A V_B$	0 to ± 10 V DC	0 to ± 10 V DC	100 K Ω	100 K Ω	0 to ± 6 V, DC	10 K Ω	2%	2%	1 7/8" x 1 3/4" x 2 3/8"
360	$V_O = K V_A V_B$	0 to ± 10 V DC	0 to 2 V, 400 CPS	100 K Ω	500 Ω	0 to ± 1 V, DC	10 K Ω	2%	2%	1 1/2" Sq. x 2 3/8"
430	$V_O = K V_A/V_B$	0 to 40 MV, 400 CPS	1.25 to 50 V, 400 CPS	100 K Ω	100 K Ω	0 to 1.4 V, 400 CPS	10 K Ω	incl. in Gain	$\pm 10\%$	1 7/8" x 1 3/4" x 2 3/8"
440	$V_O = K V_A/V_B$	0 to 1 V, 400 CPS	3 to 12 V DC	100 K Ω	100 K Ω	0 to 1.5 V, 400 CPS	10 K Ω	2%	2%	1 7/8" x 1 3/4" x 2 3/8"
441	SAME SPECIFICATIONS AS MODEL 440 - MINIATURIZED									1 1/8" x 1 7/8" x 2 3/8"

MAGNETIC AMPLIFIERS

LOW LEVEL • HIGH GAIN • FULLY ISOLATED

MODEL	NO. OF INPUTS	DC $\square$ EA. INPUT	INPUT μA DC	DC OUTPUT	LINEARITY	LOAD	POWER	Freq. and over -55 to 85°C For 10% Var. in Line Volt &		SIZE
								NULL	GAIN STABILITY	
537	4	90 $\square$	0 to ± 250	0 to ± 5 V	$\pm 0.5\%$	1 K Ω	115 V, 400 CPS	40 MV	2%	1 1/2" Sq. x 3"
550	4	700 $\square$	0 to ± 100	0 to ± 5 V	$\pm 0.25\%$	1 K Ω	115 V, 400 CPS	40 MV	2%	1 1/2" Sq. x 3"

FREQUENCY TO DC CONVERTERS

MODEL	INPUT FREQ.	INPUT VOLTAGE	INPUT IMPED.	OUTPUT	LOAD	POWER	SIZE	OPER. TEMP.
709	360 - 440 CPS	80 to 150 V RMS	50 K Ω	0 to 5 V DC	50 K Ω	28 V $\pm 10\%$ DC	1 3/4" x 1 7/8" x 2 1/4"	-40 to +71°C
718	100 - 400 CPS	30 to 115 V RMS	4 K Ω	1.25 to 5 V DC	7.5 K Ω	from Signal	1 1/2" Sq. x 2 3/8"	-55 to +95°C

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